Coastal Ocean Modeling and Observation Program: Real-Time Adaptive Sampling Networks

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LONG-TERM GOALS

A long-term COMOP goal is the construction of a real-time multi-platform adaptive sampling network coupled to an inter-disciplinary data-assimilative numerical model for use in relocatable coastal nowcasting and forecasting applications worldwide. Existing infrastructure, the availability of real-time/historical datasets, and our previous modeling experience have led to our initial focus on the New York Bight (NYB).

In the short term, the COMOP models and observation network are addressing NYB scientific questions related to

- coastal upwelling and its effects on phytoplankton, water clarity and hypoxia;
- storm-driven sediment transport and the relative roles of waves, currents, tides and realistic topography; and
- interactions of the coastal ocean with estuaries and inlets.

The focus of this proposal is the observation and modeling of coastal upwelling offshore of New Jersey. Coastal upwelling was chosen due to the large signal, the predictable locations, the multi-disciplinary appeal, and the potential for dual civilian/military use of the results.

OBJECTIVES

The year 1 objective of this 5-year program is the development of a coupled data-assimilative coastal ocean model and an adaptive coastal sampling network for the New York Bight that will be initially tested during the summer 1998 field season.

Specific 1997 objectives include:

1. configuration of the SCRUM model for the New York Bight and execution of non-assimilative sensitivity studies and hindcasts;
2. analysis of the extensive summer 1996 upwelling datasets with emphasis on the development of assimilation datasets;

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3. testing of new components of the observation network in preparation for the summer 1998 real-time exercise, including:

   (a) satellite ocean color imagery,

   (b) LEO-15 ADCP/CTD systems,

   (c) ship-towed ADCP/CTD systems, and

   (d) REMUS AUV ADCP/CTD systems; and

4. initial in situ bio-optical studies to establish the impact of episodic upwelling on the apparent and inherent optical properties, and to develop in situ techniques to separate dissolved versus particulate components allowing optical and fluorescence signatures to be deconvoluted.

APPROACH

1. A coastal circulation model, developed in part with prior support from ONR (N00014-95-1-0457), is being configured for the New York Bight. Sensitivity tests and model/data comparisons have been used to identify appropriate settings for numerical parameters (e.g., horizontal resolution) and boundary condition treatments.

2. NSF funding of the analysis of the 1996 data has been augmented with COMOP funds to produce surface fields for assimilation tests prior to the 1998 field season.

3. The above observation systems were field tested at LEO-15 as they became available, primarily during the summer 1997 upwelling field season.

4. Twice weekly cross-shelf bio-optical transects were coordinated with undulating hydrographic surveys throughout the summer upwelling season. The bio-optical surveys consisted of in situ profiles with a spectral radiometer (PRR-600), an absorption/attenuation meter (ac-9), a spectral fluorometer (SAFire), and Niskin bottle collection for phytoplankton pigmentation analysis (via High Pressure Liquid Chromatography).

WORK COMPLETED

1. Implementation of the New York Bight circulation model has been completed, and sensitivity studies have been conducted to assess model fidelity relative to the selection of values for grid resolution, boundary conditions, and initialization procedures. These sensitivity studies and model/data comparisons are the subject of an AASERT-supported dissertation (Mr. Scott Durski, N00014-93-1-0758).

2. Satellite-derived sea surface temperatures and OSCR-derived surface currents from the 1996 field season have been analyzed and overlayed for interpretation and assimilation. Pathfinder-like cloud detection algorithms modified to retain pixels near coasts and fronts were developed to provide test SST images for assimilation.

3a. Ocean color imagery from the OCTS satellite that failed in June of 1997 was acquired. The satellite data acquisition system at Rutgers was modified to include the tracking and real-time acquisition of SeaWiFS data.

3b. Regular cycling of the LEO-15 node profiler system through the water column was initiated during the summer 1997 field season. Software for the real-time analysis of LEO-15 node CTD/wave data and its display on the world wide web was developed. The first ADCP to draw power from and communicate in real-time over the LEO-15 system was deployed.

3c. The surface-towed SWATH ADCP and undulating-towed CTD systems were tested for the first time in the open ocean.

3d. REMUS AUVs completed three test runs over distances of 10, 20 and 6 km at LEO-15 during a three-day test period in early August.

4. During the summer season, over 200 vertical profiles were collected with the Bio-Spherical spectroradiometer. This data was complemented with approximately 100 vertical casts of the ac-9 and SAFire. In addition, over 250 phytoplankton pigment samples were collected and are being analyzed through a Cooperative Agreement with the Agricultural Research Service. A filtration system was constructed and was outfitted to the ac-9 and SAFire allowing the optical properties of the dissolved constituents to be determined in situ. This could be subtracted from the total optical load (determined on a replicate cast), providing the signature of the water column particulates. These specialized casts were conducted beside the LEO-15 node which was being simultaneously profiled.

RESULTS

1. In preparation for full system coupling, hindcast simulations have been conducted with a high-resolution circulation model of the New York Bight to characterize model performance and to explore alternative observation system design options. With sufficient horizontal and vertical resolution (300 meters and 1 meter, respectively) the coastal circulation model produces hindcasts of upwelling frontal evolution over a 5-day period of sufficient accuracy to positively influence sampling strategies. While hindcast quality is a sensitive function of several factors, among the most important are the adequacy of initial and boundary condition data.

2. The surface temperature and current field in the vicinity of an upwelling center are well correlated. A strong alongshore jet is observed to bend around the upwelling center, resulting in a high vorticity ridge in the vicinity of the bend. Within the upwelling center, a cyclonic eddy is observed after the relaxation of the wind field. Surface divergence (upwelling) is greatest in the middle of the upwelling center. A ring of surface convergence (downwelling) is observed just inside the upwelling front. Enhanced inertial wave energy was noted within the upwelling center as part of the NSF sponsored data analysis.

3a. The LEO-15 region was observed to have the highest concentration of phytoplankton along the U.S. east coast in the OCTS images just prior to failure.

3b. While the LEO-15 node profiler can be cycled at any desired frequency by a team of undergraduates, unattended computer operation of the profiler is not yet recommended.

3c. Simultaneous velocity, temperature and salinity sections can be obtained at optimal ship-towing speeds of 5.5 knots in the LEO-15 area in a variety of sea-states. The surface towed SWATH ADCP is limited in that it cannot be towed into a short-period windsea.

3d. REMUS AUVs were not sea-state-limited by the high waves experienced during the LEO-15 test period.

4. Upwelling leads to a dramatic enhancement of material within the nearshore upwelling center. There is also strong coherence between the edge of the upwelling front with the optical properties in time. The quantitative increases in the apparent and inherent optical properties were well over an inverse meter, and should be readily detectable by remote sensing technology. These results support the hypothesis that upwelling leads to an enhancement of material in nearshore waters which could fuel the depletion of oxygen in bottom waters. Vertical variability in the optical properties was dramatic and initial results suggest that the optical properties can be correlated with the water column temperature. This would be consistent with the upwelling scavenging material off the sea floor from the shallow Mid-Atlantic Bight and dumping it within the nearshore waters.

IMPACT/APPLICATIONS

1. Hindcast sensitivities suggest that future sampling and data assimilation strategies be chosen with emphasis on the acquisition of adequate initial and boundary condition data.

2. The observed pattern of upwelling in the middle, downwelling at the front, and enhanced inertial wave activity within the upwelling centers could effect mixing processes to be studied with the REMUS-based turbulence sensors.

3. Tests of the individual components of the real-time adaptive sampling network have highlighted the need to emphasize system integration over the winter in preparation for the summer 1998 field season.

4. The bio-optical results and experience provided invaluable training for next year, the first large field season of the COMOP program. Results will be presented at the winter AGU Ocean Sciences meetings and will potentially provide the foundation for future HyCODE applications.

TRANSITIONS

The Ship-towed ADCP/CTD system is being used for several NOAA-sponsored estuarine survey projects and a New Jersey sponsored project developing an observation and modeling system for Newark Bay.

RELATED PROJECTS

This ONR project provides long-term base support for the LEO-15 observational and modeling infrastructure, thereby facilitating two National Ocean Partnership Program (NOPP) awards led by Rutgers University. The existing infrastructure have made LEO-15 an attractive candidate site for the upcoming ONR-sponsored Hyperspectral Coastal Ocean Dynamics Experiment (HyCODE).

REFERENCES

C.J. von Alt, M.P. De Luca, S.M. Glenn, J.F. Grassle and D.B. Haidvogel, 1997. LEO-15: Monitoring & Managing Coastal Resources. *Sea Technology*, **38**, (8), pp. 10-16.